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INFLUENCE OF LONG-TERM USE OF PRIMARY TILLAGE SYSTEMS ON WEED INFESTATION OF AGROCENOSIS

V. P. Kyryliuk
Khmelnitsky State Agricultural Experimental Station of Institute of Feed Research and Agriculture Podillia of NAAS, 1 Samchyky St., Samchyky village, Starokostiantyniv district, Khmelnytskyi region, 31182, Ukraine

Topicality. *The study of the long-term use of different primary tillage systems will allow us to identify, and consequently predict, possible impacts on production from their use.* ***Purpose.*** *To study the impact of long-term use of different systems of primary tillage on weed infestation of fields.* ***Methods.*** *The research was conducted in a ten-field crop rotation of the stationary experiment in 1989–2000, five-field in 2001–2008, four-field in 2009–2016, and four-field in 2017–2022 at the Khmelnytskyi State Agricultural Experimental Station of the Institute of Feed Research and Agriculture of Podillia. In the first (1989–2000) and second (2001–2008) periods, seven systems of primary tillage were studied, including1) moldboard tillage for all crops; 2) chisel tillage for all crops; 3) combined system No.1 – surface disking under winter crops after annual crops, moldboard tillage for sugar beet, chisel tillage for all other crops; 4) combined system No.2 – surface disking for winter crops after annual crops, chisel tillage for sugar beet, moldboard tillage for all other crops; 5) subsurface tillage for all crops; 6) paraplough cultivation for all crops; 7) surface tillage – surface disking for all crops. Five systems were studied in the third (2009–2016) and fourth (2017–2022) periods: 1) moldboard tillage for all crops; 2) chisel tillage for all crops; 3) subsurface tillage for all crops; 4) disk tillage for all crops; 5) minimum tillage – shallow disk tillage for all crops, and since 2020 – differentiated tillage, which includes moldboard and moldboardless tillage in crop rotation. The crop cultivation technology is generally accepted for the zone, with the exception of the studied variants of the primary tillage systems.* ***Results.*** *The results of studies of the impact of long-term use of different systems of primary tillage on the quantitative and species composition of the weed component of agrocenosis are presented. It was found that the most favourable phytosanitary condition for all crops was observed under the moldboard system, which resulted in the lowest weed infestation, the chisel system being the closest to it. In all moldboardless systems, the number of weeds was 38–110 % higher than in the moldboard system, their vegetative air-dry weight increased by 15–47 %, and the number of species increased by 6–31 %.* ***Conclusions.*** *As a result of long-term use of different systems of primary tillage, it was found that the best phytosanitary condition for all agrocenosis was in the moldboard system, which was characterised by the lowest number and weight of weeds, the closest to it was the chisel system. In general, the number of weeds in moldboardless systems was 38–110 % higher than in moldboard systems, their vegetative air-dry weight increased by 15–47 %, and the number of species increased by 12–29 %. During 33 years, the field agrocenosis was purified from weeds due to all systems of primary tillage with a decrease in the number of weeds by 53–71 %, their vegetative air-dry mass by 52–70 %, and the number of species by 33–58 %, with the simultaneous formation of a small group of resistant species that are present in agrocenosis permanently in all systems.*

Key words: *moldboard tillage, chisel tillage, subsurface tillage, disking, weeds*

Introduction. In recent years, the debate over changes in the planet's temperature regime, which is often identified with the global warming, has been gaining in intensity. This is primarily due to the anticipated increase in the greenhouse effect and, consequently, the rise in global air temperature [1–4]. Ukrainian ecological and economic security will largely depend on the efficiency of the agriculture adaptation to the expected climate change and future natural and climatic conditions for the cultivation of crops [5].

Modern global warming is significantly changing the conditions for the growth, development and productivity of crops. Native vegetation can be replaced by new species better adapted to higher temperatures or droughts [6]. Therefore, it is important to record any changes now, since weeds have adapted to the specific crops based on the principle of similarity of biological properties [7] and predict further development of weeds in the process of longselection, which can cause significant losses [8–10]. In each crop rotation, specific weeds accom-

Author information:
Viktor P. Kyryliuk, *Candidate of Agricultural Sciences, Senior Researcher, Head of the Laboratory of Modern Technologies in Agriculture*, e-mail: hdsgds@ukr.net, https://orcid.org/0000-0001-5771-8142

pany certain crops. The species composition of weeds in field crops is represented by annual and perennial plants. Tillage is one of the ways to control weeds.

Modern agriculture in Ukraine is adopting resource-saving technology for growing field crops using soil-protective moldboardless tillage. At the same time, scientists and practitioners have a mixed view of moldboardless tillage: on the one hand, it is a more productive and cheaper tillage method that also reduces erosion, losses of organic matter and moisture from the soil, and on the other hand, consistent use of moldboardless tillage leads to increased weed infestation and decreased productivity [11]. However, there is currently no consensus on the weed control effectiveness of moldboard [12] or moldboardless [13] tillage. Nowadays, moldboardless cultivation, which is carried out with disc tools, is becoming widespread. Wide range of non-selective herbicides and the introduction of genetically modified crops have increased the implementation of minimum tillage systems, including direct seeding technologies in uncultivated soil [14]. According to A. M. Maliienko [15], weed control is more difficult and costly by 15–100 % with minimum tillage, including no-till, in comparison to moldboard tillage. The investigation of the long-term impact of different tillage systems will allow us to identify, and therefore predict, the possible effects of such practices on production.

The study aimed to examine the impact of long-term application of fundamentally different systems of primary tillage on weed infestation of agroecosystems.

Materials and Methods. The research was carried out in a ten-field crop rotation of stationary experiment in 1989–2000, and in five-field crop rotation in 2001–2008, four-field crop rotation in 2009–2016, and four-field crop rotation in 2017–2022 at the Khmelnytskyi State Agricultural Experimental Station of the Institute of Feed Research and Agriculture of Podillia. In the first (1989–2000) and second (2001–2008) periods, seven systems of primary tillage were studied, which included: 1) moldboard tillage for all crops; 2) chiseling for all crops; 3) combined system No. 1 – surface disking for winter crops after annual crops, moldboard tillage for sugar beet, and chiseling for all other crops; 4) combined system No. 2 – surface disking for winter crops after annual crops, chiseling for sugar beet, and moldboard tillage for all other crops; 5) subsurface tillage for all crops; 6) paraplough cultivation for all crops; 7) surface tillage is surface disc tillage for all crops. Five systems were studied in the third (2009–2016) and fourth (2017–2022) periods: 1) moldboard tillage for all crops; 2) chiseling for all crops; 3) subsurface tillage for all crops; 4) disking for all crops; 5) minimum tillage – shallow disking for all crops. Starting from 2020, differentiated tillage, including moldboard and moldboardless tillage in crop rotation, has been introduced.

The crop cultivation technology is generally accepted for the zone, except for the studied variants of the primary tillage systems. Tillage was carried out with a heavy disc harrow BDT-3.0 (BDT-7) to a depth of 10–12 cm (5–10 cm with the minimum system), PLN-3-35 – to a depth of 22–30 cm (depending on the crop); plough PCh-2.5 with the device PST-2.5 – to a depth of 20–40 cm, paraplough PRPV-5-50 – to a depth of 20–40 cm, subsurface plough KPG-2-150 – to a depth of 22–30 cm.

Plots were located randomly, the registration area of the plot was 80 m^2, and the experiment was repeated four times. Records and observations were carried out according to generally accepted methods [16, 17].

Results and Discussion. Over a long period of time (33 years), crop rotations and varieties of crops, herbicides and fertilisers, and weather conditions have changed; however, the only difference was the primary tillage systems, all of which had a certain impact on the weed infestation of agrocenosis (Table 1). Studies showed that the primary tillage systems significantly affected the quantitative and species composition of the weed component of agrocenosis.

Thus, in each period of research, the lowest number of weeds was recorded in the moldboard tillage system (control), and the highest number was in the disc tillage system. In terms of quantitative and weight indicators, the closest to the disc tillage system was the subsurface tillage system, and the closest to the moldboard tillage system was the chisel tillage system. Over the past two periods, the number of weeds in crops decreased in all tillage systems. This can be explained by the introduction of more

Table 1. Long-term effect of primary tillage systems on the weed infestation of crop rotation, total number of weeds in growing seasons and average in the crop rotation, plants/m^2, (1989–2022)

Tillage system	Period, years				Average	± to control	
	1989–2000	2001–2008	2009–2016	2017–2022		plants/m^2	%
Moldboard tillage (control)	226	334	228	107	224	-	-
Subsurface tillage	364	528	321	127	335	111	50
Chiseling	306	504	314	114	310	86	38
Disking	480	928	333	139	470	246	110

herbicides and, partly, by the increased incidence of drought and heat conditions during the growing season. Therefore, on average, over the years of research, the lowest number of weeds was 224 plants/m^2 under the moldboard tillage system. Under moldboardless tillage systems, the number of weeds increased by 38–110 % compared to the control, with the lowest value under the chisel tillage system and the highest value – under the subsurface tillage system. Under the disc tillage system, the weed infestation rates were close to the subsurface tillage system. Similar tendency was observed in terms of vegetative air-dry mass of weeds (Table 2).

Table 2. Long-term effect of primary tillage systems on vegetative air-dry mass of weeds, total for growing seasons and on average in crop rotation, g/m^2, (1989–2022)

Tillage system	Period, years				Average	± to control	
	1989–2000	2001–2008	2009–2016	2017–2022		g/m^2	%
Moldboard tillage (control)	69.5	34.7	54.7	33.7	48.2	-	-
Subsurface tillage	103.8	53.8	60.8	35.6	63.5	15.3	32
Chiseling	83.9	44.6	59.3	32.9	55.2	7.0	15
Disking	115.1	64.1	69.8	34.2	70.8	22.6	47

A significant change in air-dry mass of weeds was noted both during the growing season in each crop rotation and during each period and on average over the years of research. If these changes over a long-term research period are explained by different weather conditions, then in the context of a single year, weeds mass was significantly influenced by tillage (on average, the influence of tillage was 0.78, the influence of weather conditions was 0.68). On average, over the years of research, the vegetative air-dry mass of weeds in crops ranged within 48.2–70.8 g/m^2 with the lowest value in the moldboard tillage system (control) and the highest – in the disc tillage system. It should be note that the smallest reduction in air-dry mass was up to 15 % of the control under chisel tillage system. The results of long-term application of different systems of primary tillage revealed that the most favourable phytosanitary condition for all agrocenosis was observed in the moldboard system, where the number and mass of weeds were the lowest, and the closest to it was the chisel tillage system (Table 3).

On average, the number of weed species was 12–29 % higher in the moldboardless system than in the moldboard system. Thus, the quantitative and species composition of the weed component of the agrocenosis gradually decreased. Moldboard and chisel tillage systems had the highest effect on this factor, and the subsurface tillage system had the lowest.

Under the long-term effect of different systems of primary tillage, certain changes occurred in the species composition of the weed component of agrocenosis (Table 4). The first period of research (1989–2000) in ten-field crop rotation showed that the number of the most

Table 3. Long-term effect of primary tillage systems on the number of weed species, total for the growing season and on average in crop rotation, pcs/m², (1989–2022)

Tillage system	Periods, years				Average	± to control	
	1989–2000	2001–2008	2009–2016	2017–2022		pcs/m²	%
Moldboard tillage (control)	22	22	12	12	17	-	
Subsurface tillage	28	27	17	21	22	5	29
Chiseling	24	23	16	13	19	2	12
Disking	28	27	18	16	22	5	29

Table 4. Long-term effect of primary tillage systems on the species composition of weeds in agrocenosis, on average by crop rotation over the years of research, pcs./m²

Weed species		1989–2000				2017–2022			
		Moldboard (control)	Subsurface	Chiseling	Disking	Moldboard (control)	Subsurface	Chiseling	Disking
Field bindweed		*	*	*	*	-	*	*	-
Fingered speedwell		*	*	*	*	-	*	-	-
Little flower quickweed		*	*	*	*	*	*	-	*
Pale persicaria		*	*	*	*	-	*	-	-
Shepherd's purse		*	*	*	*	*	*	*	*
Common chickweed		*	*	*	*	*	*	*	*
Common dandelion		-	*	-	*	-	*	-	*
Lambsquarters		*	*	*	*	*	*	*	*
Yellow foxtail		*	*	*	*	*	*	*	*
Petty spurge		-	-	-	*	-	-	-	-
Sun spurge		*	*	*	*	-	-	-	-
Canadian thistle		*	*	*	*	-	*	-	-
European black nightshade		*	*	*	*	-	-	-	-
Catchweed		*	*	*	*	*	*	*	*
Couch grass		*	*	*	*	-	*	-	-
Barnyard grass		*	*	*	*	-	-	-	-
Ribwort plantain		-	*	-	*	-	-	-	-
Scentless mayweed		*	*	*	*	*	*	-	*
Common fumitory		*	*	*	*	-	*	-	-
Knotgrass		-	*	-	*	-	-	-	-
Yellow rocket		-	*	*	-	-	-	-	-
Field pennycress		*	*	*	*	*	*	*	*
Field pansy		*	*	*	*	-	-	-	-
Common horsetail		*	*	*	*	-	-	-	-
Redroot pigweed		*	*	*	*	*	*	*	*
Total species, pcs/m²		20	24	21	24	9	16	9	10
± to control	pcs/m²	-	4	3	4	-	7	-	1
	%	-	20	15	20	-	78	-	11
Other species, pcs/m²		2	4	3	4	3	5	4	6
± to control	pcs/m²	-	2	1	2	-	2	1	3
	%	-	100	50	100	-	67	33	100
Total, pcs/m²		22	28	24	28	12	21	13	16
± to control	pcs/m²	-	6	2	6	-	9	1	4
	%	-	27	9	27	-	75	8	33
± to period (1989–2000)	pcs/m²	-	-	-	-	-10	-7	-11	-12
	%	-	-	-	-	-45	-25	-46	-43

*Note: * – available species; '-' – no species; other species, the average number of which was 0.5 or less.*

common weed species in crop rotation depended on the primary tillage systems and varied within 20–24 species. The lowest number of weed species was under the moldboard tillage system, and the highest – under the subsurface tillage and disc tillage systems with a total number of 22–28 species, respectively. Other species were rarely observed in the crops, and their average number was less than 0.5. During this period, the following species were included in this group: cornflower (*Centaurea cyanus* L.), alfilaria (*Erodium cicutarium* L.), field poppy (*Papaver rhoeae* L.), and common sowthistle (*Sonhus oleraceus* L.). These species should be taken into account because they can have massive development, although not every year.

Sometimes a similar situation is recorded with scentless mayweed in crops of cereals, white lambsquarters or black nightshade in soybean crops, etc. During the fourth period (2017–2022), in the four-field crop rotation, the number of common species varied within 9–16, with the lowest number in the moldboard tillage system and the highest number in the subsurface tillage system, and in total, under the above systems, there were 12 and 21 species, respectively. We included the following species in the group of other species: cornflower, alfilaria, wood sorrel (*Oxalis acetosella* L.), field poppy, common sowthistle, and knotgrass (*Polygonum aviculare* L.). We should also note the red pimpernel (*Anagallis arvensis* L.), which is extremely rare during all observation periods.

A separate group consisted of the most common and resistant species observed in the crops during all periods of research, which included: shepherd's purse (*Capsella bursapastoris* L.), common chickweed (*Stellaria media* L.), lambsquarters (*Chenopodium album* L.), yellow foxtail (*Setaria glauca* L.), catchweed (*Galium aparine* L.), scentless mayweed (*Matricaria perforata* Merat.), field pennycress (*Thlaspi arvense* L.), redroot pigweed (*Amaranthus retroflexus* L.).

In the fourth period, compared to the first, the number of species decreased by 25–46 % under the moldboard tillage system; the smallest decrease was recorded under the subsurface tillage system.

On the basis of the above data, we have reached the following conclusions: the number of weeds decreased by 53–71 % in agrocenosis, their vegetative air-dry mass – by 52–70 %, and the number of species – by 25–43 % in the fourth period of research compared to the first (Table 5).

Table 5. Long-term effect of the primary tillage systems on the quantitative changes of weed components in agrocenosis (2017–2022 ± 1989–2000)

Tillage system	Number of weeds		Vegetative air-dry mass of weeds		Number of species	
	plants/m^2	%	g/m^2	%	pcs/m^2	%
Moldboard tillage (control)	-120	-53	-358	-52	-10	-45
Subsurface tillage	-238	-65	-682	-66	-7	-25
Chiseling	-193	-63	-510	-61	-11	-46
Disking	-342	-71	-810	-70	-12	-43

So, for 33 years, weeds have been removed from the agrocenosis through all the systems of primary tillage, resulting in a small group of highly resistant weed species that are permanently present in the agrocenosis. A total of 32 weed species were identified in the crop rotation.

Conclusions. As a result of long-term effect of different systems of primary tillage, it was found that the moldboard tillage system had the most favourable phytosanitary condition for all agrocenosis, with the lowest number and mass of weeds, and the chisel tillage system was the closest to it. In general, the number of weeds was 38–110 % higher in moldboardless tillage systems compared to moldboard ones, their vegetative air-dry mass was 15–47 % higher, and the number of species increased by 12–29 %. For 33 years, the field agrocenosis was cleared from weeds due to all systems of primary tillage which reduced the number of weeds by 53–71 %, their vegetative air-dry mass by

52–70 %, the number of species by 33–58 % and resulted in the formation of a small group of resistant species that are present in agrocenosis permanently under all tillage systems.

References

1. Augustin J., Couwenberg M., Minke M. (2011). Peatlands and climat. Carbon creadits from pert lands rewetting: climate-biodiversity-land use eds. Wichtmann W., Tanneberger F. Stuttgar. 2011. 13–19.
2. http: //www. unfccc. int.
3. http: //www. ipcc. ch.
4. Iglesias A., Garrote I., Quiroga S., Moneo M. (2012). A regional comparisono of the effects of climat change on agricultural crops in Europe. *Climatic Change*, *112 (1).* 29–46. doi: 10.1007|s10584-011-0338-8).
5. Mishenin, Ye. V., Oliinyk, N .V. (2010). The development of the ecosystem services market as a direction of the post-crisis growth of the Ukrainian economy. *Mekhanizm rehuliuvannia ekonomiky* [Economy regulation mechanism], *3 (2).* 104–116. [in Ukrainian].
6. Konishchuk V. V., Koval S. I. (2018). The influence of changes in weather conditions on agricultural crops. *Zemlerobstvo* [Agriculture], *2.* 30–34. [in Ukrainian].
7. Kniazieva N. A., Smyrnova S. O., Petrenko S. M., Boiko A. L. (2001). The role of litter vegetation and widespread infections in sunflower fields. *Virusy ta buriany* [Viruses and weeds], *10.* 17–18. [in Ukrainian].
8. Buka A. (2001). Advanced technologies. Silskyi zhurnal [Village magazine], *11.* 14. [in Ukrainian].
9. Borona V. P., Karasevych V. V., Solonenko V. M. (2001). Dangerous competitors of rapeseed]. *Zakhyst roslyn* [Plant protection], *10.* 19–20. [in Ukrainian].
10. Borona V. P., Zadorozhnyi V. S., Karasevych V. V., Postolovska T. T. (2002). Weed control in the forest-steppe. *Zakhyst roslyn* [Plant protection], *10.* 8–9. [in Ukrainian].
11. Medviediev V. V., Lyndina T. Ye. (2001). Scientific prerequisites of minimization of the main processing of groundnut and prospects of its implementation in Ukraine. *Visnyk ahrarnoi nauky* [Bulletin of Agrarian Science], *7.* 5–8. [in Ukrainian].
12. Manaeva N. N. (2001). Which treatment is better? *Zakhyst roslyn.* [Plant protection], *10.* 13. [in Ukrainian].
13. Yeshchenko V. O., Oprishko V. P., Karychkovskyi D. L. (2002). [It is easier to prevent than to regulate]. *Zakhyst roslyn* [Plant protection], *5.* 12. [in Ukrainian].
14. Maliienko A. M., Brukhal F. Y, Kolomiiets V. M. (2000). Autumn application of herbicides: formation and development of the weed component of winter wheat agrophytocenosis during autumn application of herbicides. *Karantyn i zakhyst roslyn* [Quarantine and plant protection]. *7.* 7–9. [in Ukrainian].
15. Maliienko A. M. (1997). Modern prerequisites for the formation of soil cultivation systems in Ukraine. Ahronom [Agronomist], *8–9.* 19–22. [in Ukrainian].
16. Maliienko A. M. et. al. (2017). *Metodychni rekomendatsii i prohrama doslidzhen po obrobitku gruntu.* Methodical recommendations and research program on soil cultivation. Kyiv: Ahrarna nauka. [in Ukrainian].
17. Dospekhov B. A. (1985). *Metodika polevoho opyta*. Methods of field experience. Moskov: Ahropromizdat. [in Russian].

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Актуальність. Вивчення довготривалого застосування різних систем основного обробітку ґрунту дозволить виявити, а отже, і передбачити можливу появу на виробництві того чи іншого ефекту від їх застосування. **Мета роботи.** Дослідити вплив тривалого застосування різних систем основного обробітку ґрунту на забур'яненість полів. **Матеріали і методи**. Дослідження проводили у десятипільній сівозміні стаціонарного досліду в 1989–2000 рр., п'ятипільній – у 2001–2008 рр., чотирипільній – у 2009–2016 рр., чотирипільній – у 2017–2022 рр. на Хмельницькій державній сільськогосподарській дослідній станції Інституту кормів та сільського господарства Поділля. У першому (1989–2000 рр.) та другому (2001–2008 рр.) періодах вивчали сім систем основного обробітку ґрунту, які передбачали: 1) полицева – полицевий обробіток під усі культури; 2) чизельна – чизельний обробіток під усі культури; 3) комбінована 1 – поверхневий дисковий обробіток під озимі після однорічних культур, полицевий під буряки цукрові, чизельний під усі інші культури; 4) комбінована 2 – поверхневий дисковий обробіток під озимі після однорічних культур, чизельний під буряки цукрові, полицевий під усі інші культури; 5) плоскорізна – плоскорізний обробіток під усі культури; 6) параплужна – параплужний обробіток під усі культури; 7) поверхнева – поверхневий дисковий під усі культури. На третьому (2009–2016 рр.) та четвертому (2017–2022 рр.) періодах вивчали п'ять систем: 1) полицева – полицевий обробіток під усі культури; 2) чизельна – чизельний обробіток під усі культури; 3) плоскорізна – плоскорізний обробіток під усі культури; 4) дискова – дисковий обробіток під усі культури; 5) мінімальна – мілкий дисковий обробіток під усі культури, а з 2020 року – диференційована, яка включає полицеві та безполицеві обробітки у сівозміні. Технологія вирощування культур – загальноприйнята для зони за виключенням досліджуваних варіантів систем основного обробітку ґрунту. **Результати.** Викладено результати досліджень впливу тривалого застосування різних систем основного обробітку ґрунту на кількісно-видовий склад бур’янового компонента агроценозів. Виявлено, що найсприятливіший для усіх сільськогосподарських культур фітосанітарний стан складався за полицевої системи, що мала найменшу забур’яненість, найближчою до неї була чизельна система. За усіх безполицевих систем кількість бур’янів була вищою за полицеву на 38–110 %, їх вегетативна повітряно-суха маса збільшувалася на 15–47 %, кількість видів зростала на 6–31 %. **Висновки.** У результаті тривалого застосування різних систем основного обробітку ґрунту виявлено, що найсприятливіший для усіх агроценозів фітосанітарний стан складався за полицевої системи, де виявлено найменшу кількість та масу бур’янів, найближчою до неї була чизельна систем. Взагалі, за безполицевих систем кількість бур’янів була вищою за полицеву на 38–110 %, їх вегетативна повітряно-суха маса зростала на 15–47 %, кількість видів збільшувалася на 12–29 %. Впродовж 33 років відбувалося очищення агроценозу поля від бур’янів за усіх систем основного обробітку ґрунту зі зменшенням кількості бур’янів на 53–71 %, їх вегетативної повітряно-сухої маси – на 52–70 %, кількості видів – на 33–58 % з одночасним утворенням невеликої групи стійких видів, що присутні в агроценозах постійно за усіх систем.

***Ключові слова**: полицева, чизельна, плоскорізна, дискова, бур’яни*